PB-240 511

SPRING LAKE, WASHINGTON AND DAKOTA COUNTIES, MINNESOTA

Pacific Northwest Environmental Research Laboratory

Prepared for:

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Minnesota National Guard

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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REPORT
ON
SPRING LAKE
WASHINGTON AND DAKOTA COUNTIES
MINNESOTA

EPA REGION V

WORKING PAPER No. 127

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

JANUARY, 1975

II

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

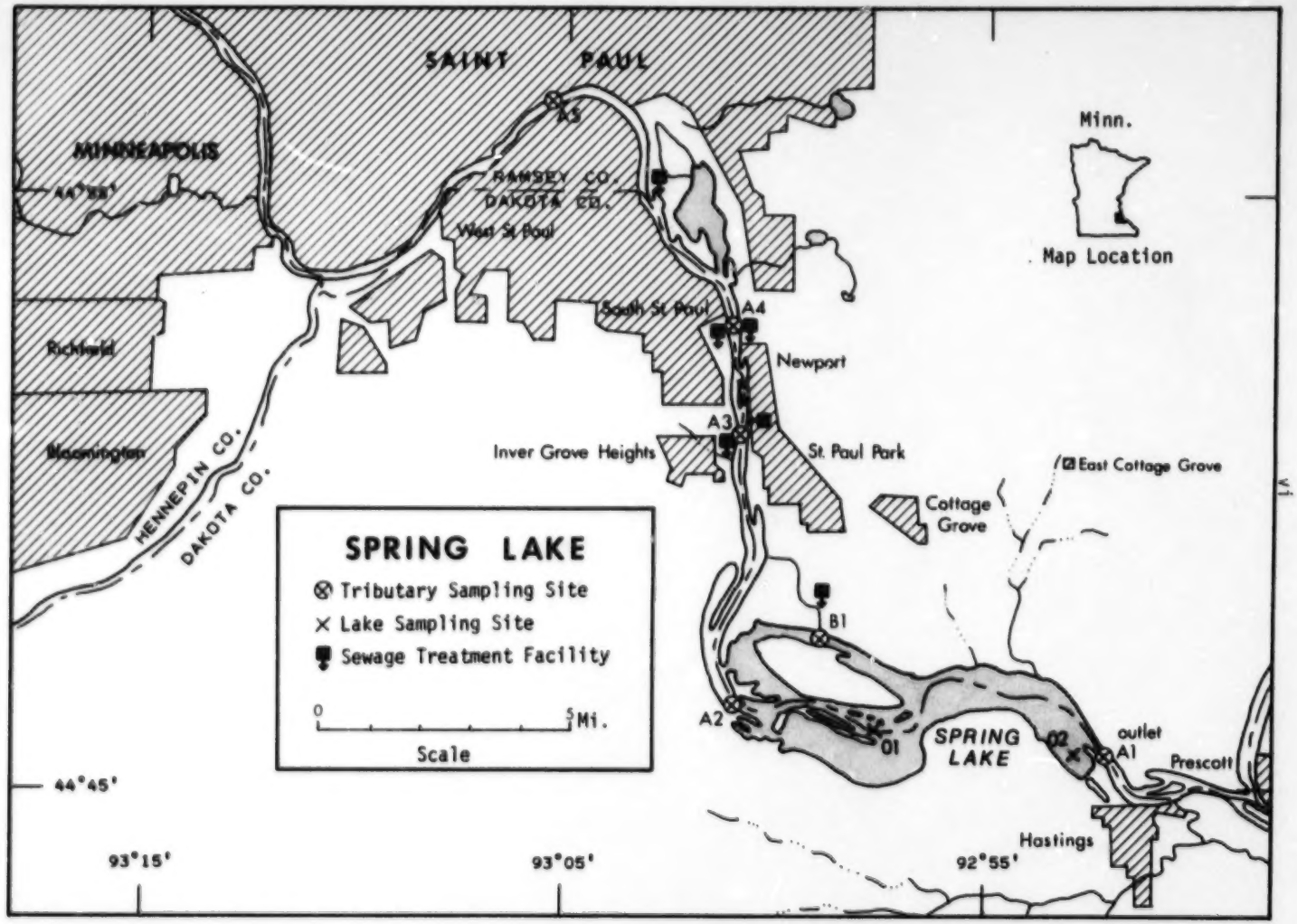
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Hennepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


SAINT PAUL
MINNEAPOLIS
44°58'
RAMSEY CO.
DAKOTA CO.
West St. Paul
A5
Minn.
Map Location
South St. Paul
A4
Newport
A3
Inver Grove Heights
St. Paul Park
East Cottage Grove
Cottage Grove
Richfield
Bloomington
HENNEPIN CO.
DAKOTA CO.
SPRING LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0
5 Mi.
Scale
B1
A2
01
SPRING LAKE
02
outlet
A1
Prescott
Hastings
44°45'
93°15'
93°05'
92°55'

SPRING LAKE

STORET NO. 27A6

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Spring Lake is eutrophic. Of the 60 Minnesota lakes sampled in the fall of 1972, when essentially all were well-mixed, 45 had less mean total phosphorus, and 55 had less mean inorganic nitrogen. Of all 80 Minnesota lakes sampled, 41 had less mean chlorophyll a, and only ten had less Secchi disc transparency.

Reportedly, no particular aquatic nuisance problems, other than siltation, are known for Spring Lake (Schilling, 1975).

B. Rate-Limiting Nutrient:

Algal assay results show that Spring Lake was nitrogen limited at the time the assay sample was collected. The lake data indicate nitrogen limitation at the other sampling times as well (N/P ratios were less than 11/1).

C. Nutrient Controllability:

1. Point sources--During the sampling year, Spring Lake received a total phosphorus load at a rate nearly 30 times the rate proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 14). Now, the mean hydraulic retention time of Spring Lake is less than 60 hours, and Vollenweider's

model probably is not applicable. Nonetheless, the present trophic condition of Spring Lake is evidence of excessive nutrient loads.

It is calculated that even complete removal of phosphorus at the point sources included in this study would still leave a phosphorus loading rate about 15 times the eutrophic rate. However, in view of the questionable applicability of Vollenweider's model to Spring Lake, and the effect of reduced loadings on the quality of downstream waters, phosphorus control is indicated.

Point-source phosphorus control would not be expected to result in a mesotrophic condition in Spring Lake but should improve the existing trophic condition. Also, it is likely that downstream Lake Pepin* would benefit from the reduced phosphorus load to the system.

2. Non-point sources (see page 14)--During the sampling year, the mean phosphorus export of the Mississippi River at station A-5 was just over twice the mean phosphorus export of the Mississippi at four near-headwater lakes** included in the Survey; i.e., 37 lbs P/mi^2/yr (range = 24 to 45 lbs/mi^2/yr).

This doubling of phosphorus export may have been due only to changes in land-use practices from the largely-forested

* Working Paper No. 119.
** Lakes Andrusia (WP #81), Bemidji (WP #84), Cass (WP #92), and Wolf (WP #136).

headwaters area to the more intensively agricultural and urbanized areas near Spring Lake. It seems probable, though, that at least part of the export increase was due to incremental contributions of point-source phosphorus along the course of the river and its tributaries.

In all, it is calculated that non-point sources contributed nearly 51% of the total phosphorus load to Spring Lake during the sampling year.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry†:

1. Surface area: 5,910 acres.
2. Mean depth: 8 feet.
3. Maximum depth: 20 feet.
4. Volume: 47,280 acre-feet.
5. Mean hydraulic retention time: 2½ days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
Mississippi River	36,800.0 mi^2	9,895.0 cfs
Minor tributaries & immediate drainage -	390.8 mi^2	243.3 cfs
Totals	37,190.8 mi^2	10,138.3 cfs

2. Outlet -

Mississippi River**	37,200.0 mi^2	10,138.3 cfs

C. Precipitation***:

1. Year of sampling: 35.1 inches.
2. Mean annual: 24.4 inches.

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† Schilling, 1974.
* Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Spring Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from two or more depths at each station (see map, page vi). During each visit, a single depth-integrated (near bottom to surface) sample was collected from the stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was collected for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 11 feet at station 1 and 15 feet at station 2.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/04/72)		
Temperature (Cent.)	6.1	6.1	6.1	6.2
Dissolved oxygen (mg/l)	10.6	11.0	11.0	11.4
Conductivity (μmhos)	490	507	510	520
pH (units)	7.8	7.9	7.9	7.9
Alkalinity (mg/l)	176	180	180	184
Total P (mg/l)	0.192	0.218	0.217	0.245
Dissolved P (mg/l)	0.120	0.139	0.138	0.160
NO_2 + NO_3 (mg/l)	0.950	1.168	1.170	1.390
Ammonia (mg/l)	0.390	0.418	0.405	0.460
		ALL VALUES		
Secchi disc (inches)	12	20	21	24

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/28/72	1. Stephanodiscus	4,000
	2. Melosira	2,189
	3. Scenedesmus	566
	4. Rhaphidiopsis	490
	5. Gloeocapsa	453
	Other genera	1,925
	Total	9,623
09/03/72	1. Melosira	814
	2. Raphidiopsis	524
	3. Cyclotella	380
	4. Synedra	325
	5. Scenedesmus	325
	Other genera	2,189
	Total	4,557
11/04/72	1. Cyclotella	8,571
	2. Flagellates	1,278
	3. Microcystis	1,128
	4. Fragilaria	677
	5. Navicula	526
	Other genera	3,309
	Total	15,489

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (ug/l)
06/28/72	01	27.5
	02	34.5
09/03/72	01	7.6
	02	8.8
11/04/72	01	30.0
	02	22.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.096	1.430	34.5
0.005 P	0.101	1.430	34.8
0.010 P	0.106	1.430	35.2
0.020 P	0.116	1.430	36.9
0.050 P	0.146	1.430	37.6
0.050 P + 10.0 N	0.146	11.430	68.3
10.0 N	0.096	11.430	49.3

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Spring Lake was very high at the time the sample was taken. Also, the lack of any significant change in [illegible] with increased levels of orthophosphorus, until [illegible] was also added, shows that this lake was nitrogen limited. Note that

with the addition of only nitrogen there was a significant increase in yield over the control yield.

Nitrogen limitation is also indicated by the lake data for each of the three sampling dates; i.e., nitrogen to phosphorus ratios were less than 11 to 1 on all occasions.

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May when two samples were collected at most stations. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the means of the nutrient loads, in $lbs/mi^2/year$, at stations C-1, H-1, J-1, and K-1 of nearby Lake Pepin and multiplying the means by the ZZ area in mi^2.

The operators of the Metropolitan, Newport, St. Paul Park, South St. Paul, and Cottage Grove wastewater treatment plants provided monthly effluent samples and corresponding flow data.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Metro-politan	1,385,400	act. sludge	188.909	Mississippi River
Newport	2,922	act. sludge	0.180	Mississippi River
St. Paul Park	5,587	trickling filter	0.201	Mississippi River
Cottage Grove	13,419	act. sludge	0.931	Mississippi River
InverGrove Hts - South St. Paul	37,164	trickling filter	10.210	Mississippi River

2. Industrial - Unknown

* Anonymous, 1974.

B. Annual Total Phosphorus Loading - Sampling Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Mississippi River	2,793,030	49.4
b. Minor tributaries & immediate drainage (non-point load) -	66,140	1.1
c. Known municipal STP's -		
Cottage Grove	39,310	0.7
Metropolitan	2,480,300	43.9
Newport	5,180	0.1
St. Paul Park	8,230	0.1
InverGrove Hts. - South St. Paul	257,440	4.6
d. Septic tanks - Unknown	-	-
e. Industrial - Unknown	-	-
f. Direct precipitation* -	920	<0.1
Total	5,650,550	100.0

2. Outputs -

Lake outlet - Mississippi River	5,488,600

3. Net annual P accumulation - 161,950 pounds

* Estimated.

C. Annual Total Nitrogen Loading - Sampling Year:

1. Inputs -

Source	lbs N/yr	% of total
a. Tributaries (non-point load) -		
Mississippi River	57,238,330	84.8
b. Minor tributaries & immediate drainage (non-point load) -	817,770	1.2
c. Known municipal STP's -		
Cottage Grove	108,500	0.2
Metropolitan	8,148,990	12.1
Newport	18,020	<0.1
St. Paul Park	27,820	<0.1
InverGrove Hts. - South St. Paul	1,067,500	1.6
d. Septic tanks - Unknown	-	-
e. Industrial - Unknown	-	-
f. Direct precipitation* -	56,940	0.1
Total	67,483,870	100.0

2. Outputs -

Lake outlet - Mississippi River	75,123,930

3. Net annual N loss - 7,640,060 pounds

* Estimated.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Mississippi River (at A-5)	76	1,555

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving water would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with very short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	956.1	27.4	11,418.6	loss*
grams/m^2/yr	107.16	3.07	1,279.8	-

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time of Spring Lake:

"Dangerous" (eutrophic rate)	3.60
"Permissible" (oligotrophic rate)	1.80

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, or unknown and unsampled point sources discharging directly to the lake (e.g., shoreline septic tanks). Whatever the cause, similar nitrogen loss has occurred at Shagawa Lake which has been intensively studied by EPA's National Eutrophication Research and Lake Restoration Branch.

V. LITERATURE REVIEWED

Anonymous, 1974. Wastewater disposal facilities inventory. MPCA, Minneapolis.

Schilling, Joel, 1974. Personal communication (morphometry of Spring Lake). MPCA, Minneapolis.

_____, 1975. Personal communication (aquatic nuisance conditions in Spring Lake). MPCA, Minneapolis.

Vollenweider, Richard A. (in press). Input-output models. Schweiz. Z. Hydrol.

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 27AA SPRING LAKE

TOTAL DRAINAGE AREA OF LAKE 37200.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
27AAA1	37200.00	3752.4	3424.4	9495.5	23411.0	18018.0	16447.0	13156.0	7987.8	7434.5	7372.5	6121.9	4440.1	10138.2
27AAA2	34400.00	3440.0	3730.5	9240.0	22830.0	17570.0	16140.0	12830.0	7790.0	7250.0	7190.0	5970.8	4330.8	9895.0
27AAZZ	400.00	90.10	91.80	228.00	562.00	432.00	395.00	316.00	192.00	178.00	177.00	147.00	106.00	243.29

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 37200.00
SUM OF SUB-DRAINAGE AREAS = 37200.00

TOTAL FLOW IN = 121464.75
TOTAL FLOW OUT = 121461.75

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
27AAA1	10	72	11200.00	15	11300.00				
	11	72	16300.00	5	16400.00				
	12	72	8520.00	2	8300.00	10	7300.00		
	1	73	8420.00						
	2	73	7420.00	10	8130.00				
	3	73	32100.00	17	51400.00				
	4	73	25251.00	3	32300.00	14	18800.00		
	5	73	23680.00	19	18700.00				
	6	73	5960.00	11	16800.00				
	7	73	6120.00	14	6100.00				
	8	73	7900.00	26	8600.00				
	9	73	6200.00	22	5300.00				
27AAA2	10	72	10900.00	15	11000.00				
	11	72	15900.00	5	17900.00				
	12	72	8320.00	2	9550.00	10	8390.00		
	1	73	8210.00						
	2	73	7630.00	25	6520.00				
	3	73	31300.00	25	43100.00				
	4	73	22780.00	15	18700.00	29	14400.00		
	5	73	21400.00	7	24600.00	20	17700.00		
	6	73	5815.00	30	8430.00				
	7	73	5420.00	22	3780.00				
	8	73	7770.00	25	9360.00				
	9	73	5470.00	23	4110.00				
27AAZZ	10	72	269.00	15	270.00				
	11	72	391.00	5	442.00				
	12	72	203.00	2	233.00	10	205.00		
	1	73	202.00						
	2	73	147.00	10	194.00	25	148.00		
	3	73	771.00	17	1233.00	25	1060.00		
	4	73	1450.00	3	999.00	14	999.00	15	6470.00
	5	73	441.00	7	547.00	19	172.00		
	6	73	134.00	11	100.00				
	7	73	156.00	14	200.00	22	100.00		
	8	73	256.00	25	150.00	26	150.00		
	9	73	400.00	22	200.00	23	200.00		

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

27A601
44 46 05.0 092 57 42.0
SPRING LAKE
27 MINNESOTA

11EPALES
3

2111202
0011 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/28	16 45	0000	23.3	6.3	12	550	7.69	218	1.600	0.300	0.299	0.210
	16 45	0010	23.3	6.3				220	1.600	0.330	0.279	0.212
72/09/03	11 40	0000			24	360	7.80	150	0.420	0.360	0.215	0.164
	11 40	0004	19.9	7.9		360	7.80	150	0.430	0.350	0.216	0.157
	11 40	0009	19.8	7.8		340	7.78	147	0.430	0.370	0.250	0.168
72/11/04	14 00	0000			23	520	7.90	183	1.390	0.400	0.192	0.120
	14 00	0004	6.2	11.4		520	7.90	184	1.360	0.390	0.193	0.123
	14 00	0011	6.2	11.4		520	7.90	181	1.370	0.400	0.193	0.123

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/28	16 45	0000	27.5J
72/09/03	11 40	0000	7.6J
72/11/04	14 00	0000	30.0J

J VALUE KNOWN TO BE IN ERROR

61

STORET RETRIEVAL DATE 74/10/30

27A602
44 45 30.0 092 52 43.0
SPRING LAKE
27 MINNESOTA

11EPALFS
3

2111202
0020 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/28	17 05	0000	23.5	8.8		540	7.73	212	1.600	0.390	0.284	0.190
	17 05	0015	23.2	6.7		540	7.70	208	1.600	0.410	0.270	0.201
72/09/03	12 05	0000			18	340	7.70	152	0.470	0.400	0.197	0.150
	12 05	0004	20.0	7.0		345	7.70	154	0.460	0.390	0.234	0.150
	12 05	0015	20.0	7.4		340	7.70	152	0.470	0.390	0.239	0.154
72/11/04	13 45	0000			21	500	7.40	176	0.980	0.410	0.241	0.154
	13 45	0004	6.1	10.6		490	7.80	179	0.950	0.450	0.242	0.160
	13 45	0014	6.1	10.6		490	7.90	179	0.960	0.460	0.245	0.155

20

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/28	17 05	0000	34.5J
72/09/03	12 05	0000	8.4J
72/11/04	13 45	0000	32.1J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/30

27A6A1 LS27A6A1
44 45 30.0 092 52 30.0
MISSISSIPPI RIVER
27 CO #19. SHEET #2
O/SPRING LAKE
US LOCK & DAM 2 N EDGE OF HASTINGS
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/11/05	08 45		1.960	1.500	0.350	0.115	0.210
72/12/02	10 30		1.900	1.845	0.620	0.170	0.252
73/03/17	10 30		2.400	2.200	0.520	0.147	0.390
73/04/03	09 30		2.600	2.100	0.360	0.091	0.190
73/04/14	09 30		2.020	2.100	0.230	0.052	0.210
73/05/19	09 45		2.800	1.320	0.198	0.072	0.220
73/06/11	08 50		2.900	2.000	0.252	0.115	0.250
73/07/14	10 30		2.200	1.260	0.033	0.240	0.350
73/08/26	11 00		0.240	1.680	0.590	0.189	0.290
73/09/22	10 50		0.315	2.300	0.970	0.260	0.390

22

STORET RETRIEVAL DATE 74/10/30

27A6A2 LS27A6A2
44 46 30.0 093 01 00.0
MISSISSIPPI RIVER
27 7.5 INVER GROVE
I/SPRING LAKE
BR SPLE 0.75 ESE PINE BEND
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	15 00		0.026	1.750	0.470	0.120	0.231
72/11/05	07 50		0.950	1.500	0.370	0.100	0.189
73/01/21	08 45		1.200	2.100	0.670	0.160	0.290
73/02/25	08 45		0.940	1.700	0.670	0.194	0.320
73/03/25	10 37		3.700	2.000	0.189	0.093	0.210
73/04/15	08 30		2.040	1.680	0.132	0.066	0.190
73/04/29	08 00		2.400	3.000	0.280	0.065	0.185
73/05/07	16 00		5.500	2.200	0.126	0.092	0.195
73/05/20	10 30		2.600	2.450	0.420	0.063	0.170
73/06/29	12 37		2.500	2.100	0.615	0.205	0.345
73/07/22	08 30		0.510	2.400	0.830	0.300	0.430
73/08/25	11 30		0.260	1.400	0.350	0.190	0.310
73/09/23	14 00		0.350	2.100	0.690	0.220	0.390

23

STORET RETRIEVAL DATE 74/10/30

27A6A3 LS27A6A3
44 53 00.0 093 01 00.0
MISSISSIPPI
27 15 ST PAUL
T/SPRING LAKE
CO HWY 20 BRDG BETW INVER GROVE &ST PAUL
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	15 45		0.020	1.450	0.240	0.089	0.198
72/11/05	08 30		0.950	1.500	0.265	0.089	0.180
72/12/10	09 30		1.800	2.500	0.660	0.190	0.370
73/01/21	09 40		1.200	1.980	0.770	0.168	0.315
73/02/25	09 30		0.960	2.200	0.890	0.210	0.380
73/03/25	10 02		3.600	2.200	0.200	0.099	0.210
73/04/15	09 30		2.060	1.760	0.099	0.037	0.165
73/04/29	09 30		1.700	2.300	0.092	0.050	0.160
73/05/07	17 30		5.500	1.900	0.198	0.160	0.220
73/05/20	09 30		2.700	1.980	0.078	0.050	0.155
73/06/29	12 58		2.200	2.200	0.450	0.200	0.360
73/07/22	09 20		0.470	2.310	0.750	0.310	0.470
73/08/25	10 15		0.240	1.680	0.650	0.220	0.360
73/09/22	15 00		0.132	2.200	0.950	0.270	0.390

STORET RETRIEVAL DATE 74/10/30

27A6A4 LS27A6A4
44 57 00.0 093 04 30.0
MISSIPPI RIVER
27 15 ST PAUL
T/SPRING LAKE
AT I 494 BRDG BETW NEWPORT & S ST PAUL
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	16	35	0.450	1.600	0.260	0.140	0.280
72/11/05	09	30	0.455	1.800	0.400	0.180	0.330
72/12/10	08	35	1.600	2.600	0.690	0.230	0.380
73/01/21	10	15	1.180	1.900	0.630	0.154	0.340
73/02/25	10	00	0.920	1.900	0.700	0.180	0.370
73/03/25	09	20	2.900	2.350	0.480	0.147	0.360
73/04/15	10	00	1.820	2.310	0.370	0.098	0.270
73/04/29	10	30	2.000	3.000	0.360	0.140	0.315
73/05/07	18	30	5.000	2.700	0.310	0.154	0.290
73/05/20	08	40	2.400	2.500	0.460	0.140	0.290
73/06/29	13	18	2.200	2.000	0.320	0.180	0.320
73/07/22	10	00	0.440	2.730	0.870	0.294	0.480
73/08/25	09	45	0.260	1.470	0.399	0.220	0.330
73/09/23	15	30	0.150	1.800	0.650	0.270	0.420

STORET RETRIEVAL DATE 74/10/30

27A6A5 LS27A6A5
44 57 00.0 093 04 30.0
MISSISSIPPI
27 15 ST PAUL
T/SPRING LAKE
ST HWY 56 BRDG AT RVSD IND PARK
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/15	17 00		0.340	1.100	0.078	0.038	0.105
72/11/05	10 35		1.100	1.000	0.110	0.058	0.126
72/12/10	07 30		1.360	1.100	0.200	0.056	0.096
73/01/21	10 45		1.220	1.050	0.280	0.096	0.145
73/02/25	10 35		0.940	0.840	0.220	0.080	0.100
73/03/25	08 00		2.300	2.200	0.220	0.096	0.270
73/04/15	11 00		1.560	1.700	0.040	0.091	0.175
73/04/29	11 30		1.800	2.700	0.052	0.025	0.130
73/05/07	19 30		4.900	1.980	0.044	0.069	0.165
73/05/20	07 40		2.400	2.730	0.105	0.034	0.150
73/06/30	09 55		1.960	0.960	0.115	0.067	0.160
73/07/22	10 30		0.460	1.260	0.150	0.075	0.160
73/08/25	09 00		0.240	2.310	0.108	0.080	0.150
73/09/23	16 15		0.115	0.840	0.090	0.071	0.145

STORET RETRIEVAL DATE 74/10/30

27A681 LS27A681
44 47 30.0 092 58 30.0
GREY CLOUD CHANNEL
27 CO #82, SHEET #1
I/SPRING LAKE
BRDG 1.5 MI SSW COTTAGE GROVE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/11/05	09 45		1.100	1.500	0.115	0.056	0.176
72/12/02	11 30		1.580	1.845	0.160	0.024	0.138
73/03/17	09 00		2.000	1.950	0.680	0.168	0.270
73/04/03	08 45		2.400	1.700	0.098	0.058	0.175
73/04/14	08 30		1.440	2.200	0.053	0.015	0.130
73/05/19	08 45		1.740	3.150	0.044	0.017	0.195
73/06/11	08 40		2.900	2.000	0.260	0.115	0.270
73/07/14	09 20		0.044	2.600	0.970	0.140	0.280
73/08/25	10 15		0.090	2.300	0.126	0.069	0.260
73/09/22	09 30		0.011	2.360	0.026	0.038	0.220

27

STORET RETRIEVAL DATE 74/10/30

27A651 AS27A651 P1305400
44 55 30.0 093 02 30.0
METROPOLITAN
27 15 ST PAUL
D/SPRING LAKE
MISSISSIPPI RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/02/24	00 00								
CP(T)-			0.070	22.000	4.200	2.900	5.900	202.000	
73/02/28	24 00								
73/03/06	07 00								
CP(T)-			0.055	12.000	1.470	1.800	4.200	227.000	190.000
73/03/07	07 00								
73/04/04	00 00								
CP(T)-			0.060	17.400	5.600	2.150	4.100	198.000	213.000
73/04/05	24 00								
73/05/03	07 00								
CP(T)-			0.056	12.000	1.480	1.170	2.800	216.000	198.000
73/05/04	07 00								
73/06/01	07 00								
CP(T)-			0.220	12.600	2.300	2.100	3.450	230.000	219.000
73/06/02	07 00								
73/07/09	07 00								
CP(T)-			0.070	13.800	3.400	2.100	3.500	231.000	218.000
73/07/10	07 00								
73/08/06	07 00								
CP(T)-			0.090	13.000	1.980	2.720	4.000	245.000	215.000
73/08/07	07 00								
73/09/06	07 00								
CP(T)-				14.450	2.090	2.700	5.000	214.000	225.000
73/09/07	07 00								
73/10/04	07 00								
CP(T)-			0.190	16.000	2.300	2.500	4.100	200.000	201.000
73/10/05	07 00								
73/11/02	07 00								
CP(T)-			0.130	11.000	1.100	2.000	4.800	183.000	194.000
73/11/03	07 00								
73/12/04	07 00								
CP(T)-			0.140	16.000	3.200	3.150	6.700	184.000	183.000
73/12/05	07 00								

28

STORET RETRIEVAL DATE 74/10/30

27A652 IF27A652 P025016*
44 52 30.0 093 02 00.0
S ST PAUL
27 1S ST PAUL
D/SPRING LAKE
MISSISSIPPI RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/02/26	08	00							
CP(T)-			0.035	25.000L	21.000	7.560		8.980	8.530
73/02/27	07	00							
73/03/06	08	00							
CP(T)-			0.145	35.700	23.100	5.900	6.800	13.300	9.730
73/03/07	07	00							
73/04/04	08	00							
CP(T)-			0.045	29.000	15.600	5.300	5.900	10.400	12.500
73/04/04	13	00							
73/05/03	08	00							
CP(T)-			0.315	31.000	13.800	5.100	5.950	11.700	10.300
73/05/04	07	00							
73/05/31	08	00							
CP(T)-			0.075	31.000	19.600	7.000	8.000	10.400	10.100
73/06/01	07	00							
73/07/02	08	00							
CP(T)-			0.150	35.000	22.000	5.500	8.400	10.500	9.660
73/07/03	07	00							
73/08/06	08	00							
CP(T)-			0.190	31.450	7.900	6.500	7.400	11.800	9.190
73/08/07	07	00							
73/09/05	08	00							
CP(T)-			0.730	29.900		6.000		9.240	10.000
73/09/06	07	00							
73/10/04	08	00	0.168	39.000	20.000	4.000	9.700	40.200	13.600
73/11/12	07	00							
CP(T)-			0.380	40.000	23.000	8.200	8.800	9.940	9.800
73/11/13	07	00							
73/12/02	08	00							
CP(T)-			0.010K	33.000	20.000	7.100	8.200	10.300	9.500
73/12/03	07	00							

STORET RETRIEVAL DATE 74/10/30

27A653 AS27A653 P002922
44 53 00.0 093 00 30.0
NEWPORT
27 15 ST PAUL
D/SPRING LAKE
MISSISSIPPI RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/02/26 CP(T)- 73/02/26	11 00 13 00		0.020	33.000	4.400	8.800	11.000	0.154	0.148
73/03/06 CP(T)- 73/03/06	11 00 13 00		0.045	28.000	10.400	8.200	9.600	0.219	0.182
73/04/04 CP(T)- 73/04/04	11 00 13 00		0.025	35.000	13.800	9.950	11.000	0.174	0.137
73/05/03 CP(T)- 73/05/03	10 00 12 00		0.240	35.000	18.300	4.950	7.300	0.301	0.294
73/06/01 CP(T)- 73/06/01	11 00 13 00		0.100	35.700	10.500	5.600	7.900	0.184	0.207
73/07/02 CP(T)- 73/07/02	11 00 13 00		0.140	25.200	0.340	5.800	8.300	0.184	0.160
73/08/07 CP(T)- 73/08/07	11 00 13 00							0.167	0.160
73/09/04 CP(T)- 73/09/04	11 00 13 00		0.126	27.300			9.200	0.191	0.179
73/10/04 CP(T)- 73/10/04	11 00 13 00		0.070	48.000	22.500	1.320	11.500	0.200	0.174
73/11/02 CP(T)- 73/11/02	11 00 13 00		0.150	33.000	11.000	6.000	9.900	0.190	0.152
73/12/03 CP(T)- 73/12/03	11 00 13 00		0.020	33.000	19.000	4.350	7.000	0.168	0.179
74/01/08 CP(T)- 74/01/08	11 00 13 00		0.400	24.000	11.600	9.800	12.500	0.171	0.171

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STORET RETRIEVAL DATE 74/10/30

27A654 TF27A654 P005587
44 51 30.0 093 00 30.0
ST PAUL PARK
27 7.5 INVERGROVE H
D/SPRING LAKE
MISSISSIPPI RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/02/26	11	00							
CP(T)-			0.195	57.000	20.000	11.600	14.000	0.306	
73/02/26	13	00							
73/03/06	11	00							
CP(T)-			0.125	48.000	33.600	13.000	14.500	0.310	
73/03/06	13	00							
73/04/04	11	00							
CP(T)-			0.115	44.000		11.400	13.000	0.320	0.240
73/04/04	13	00							
73/05/02	10	00							
CP(T)-			0.215	39.900	22.500	9.300	11.000	0.342	0.290
73/05/02	12	00							
73/06/01	11	00							
CP(T)-			0.290	47.000	2.300	2.200	13.800	0.345	0.240
73/06/01	13	00							
73/07/02	11	00							
CP(T)-			0.580	29.000	11.600	9.200	10.500	0.280	0.260
73/07/02	13	00							
73/08/07	11	00							
CP(T)-								0.320	0.220
73/08/07	13	00							
73/09/05	11	00							
CP(T)-			0.500	50.000			13.600	0.254	0.175
73/09/05	13	00							
73/10/04	11	00							
CP(T)-			0.480	46.000	34.000	9.500	13.000	0.370	0.202
73/10/04	13	00							
73/11/02	11	00							
CP(T)-			0.800	51.000	9.000	3.750	16.500	0.392	0.280
73/11/02	13	00							
73/12/03	11	00							
CP(T)-			0.800	54.000	40.500	7.800	14.000	0.323	0.295
73/12/03	13	00							
74/01/08	11	00							
CP(T)-			0.440	28.000	16.000	10.400	13.000	0.352	0.230
74/01/08	13	00							

STORET RETRIEVAL DATE 74/10/30

27A656 AS27A656 P013419
44 48 00.0 092 58 30.0
COTTAGE GROVE
27 CO #82 SHEET #1
D/SPRING LAKE
MISSISSIPPI
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/02/26	11 00								
CP(T)-			0.020	49.000	19.000	10.400	15.000	0.966	0.940
73/02/26	13 00								
73/03/06	11 00								
CP(T)-			1.790	27.000	13.600	8.900	10.000	1.050	0.904
73/03/06	13 00								
73/04/04	11 00								
CP(T)-			0.025	34.000	16.400	9.900	12.000	0.900	1.000
73/04/04	13 00								
73/05/03	11 00								
CP(T)-			0.230	34.000	13.000	7.750	11.500		0.965
73/05/03	13 00								
73/06/01	11 00								
CP(T)-			0.046	35.000	15.300	2.500	13.000	0.950	0.950
73/06/01	13 00								
73/07/02	11 00								
CP(T)-			0.130	29.000	16.000	10.600	14.000	0.892	0.918
73/07/02	13 00								
73/08/07	11 00								
CP(T)-								1.050	0.919
73/08/07	13 00								
73/09/05	11 00								
CP(T)-			0.550	14.400		5.250		1.040	0.900
73/09/05	13 00								
73/10/04	11 00								
CP(T)-			10.600	39.900	17.900	8.900	16.000	0.934	0.930
73/10/04	13 00								
73/11/02	11 00								
CP(T)-			0.045	71.500	20.000	8.200	23.000	0.937	0.926
73/11/02	13 00								
73/12/03	11 00								
CP(T)-			0.170	34.000	16.000	6.700	14.000	0.888	0.900
73/12/03	13 00								
74/01/08	11 00								
CP(T)-			0.160	37.500	25.000	6.300	7.900	0.994	0.947
74/01/08	13 00								

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